STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
OFFICE OF PROCUREMENT AND CONTRACTS
1900 ROYAL OAKS DRIVE
SACRAMENTO, CA 95819
PHONE (916) 322-2137

SPECIFICATIONS FOR REFLECTIVE SHEETING SIGNS SINGLE SHEET (FRAMED AND UNFRAMED)

DRAFT

I. SCOPE

This Contract is for the fabrication and delivery of single sheet (framed and unframed) signs for use on State of California (State) highways. These specifications define the minimum requirements and performance for aluminum or Fiberglass Reinforced Plastic (FRP) substrate retroreflectorized with retroreflective sheeting. The Contractor shall fabricate and deliver signs in accordance with these specifications.

II. GENERAL

A. Workmanship

All items shall be new. The material and workmanship shall be of the best quality for the purpose.

B. Contractor's Quality Control

No later than ten days prior to fabrication of the signs, the Contractor shall submit a copy of its quality control program to the California Department of Transportation (Caltrans) Transportation Laboratory at 5900 Folsom Blvd, Sacramento, CA 95819 (c/o Lisa Dobeck). Fabrication of signs shall not commence until the Caltrans Transportation Laboratory has approved the Contractor's quality control program in writing. The quality control program shall include, but not necessarily be limited to, the following items:

1. Identification of the person responsible for quality control and their authority in the organization.
2. Basis of acceptance of incoming raw materials.
3. The type, method and frequency of quality control testing.
4. Method for recording quality control data.
5. Inspection procedures.
6. List (by manufacturer and trade name) of screening inks and process pastes, overlay films and coatings, and retroreflective sheeting materials; list of solvents each product is resistant to and recommended cleaning procedure for each product.
7. Technique for marking signs as described in Section II.C. -- "Sign Identification" of these specifications.
8. Planned coding system as described in Section III.A.7.b. – "Identification" of these specifications.

C. Sign Identification

The following notation shall be located on the lower right side of the sign when viewed from the back so as not to fall behind any post or frame member: (1) PROPERTY STATE OF CALIFORNIA, (2) the name of the Contractor, (3) the month and year of fabrication, (4) the State contract number of this Contract, and (5) the retroreflective sheeting manufacturer's identification and lot number. The notation shall be applied directly to aluminum signs in ¼ inch letters and numerals by means of die-stamp or equivalent method for FRP signs. Painting, inking, or engraving is not acceptable. The notation shall be applied in a manner that does not damage the finished sign.

All signs produced with anti-graffiti film or coating shall be marked with a 3/8 inch black dot on the face of the sign in the upper right corner before applying the film or coating. The 3/8 inch black dot shall be non-reflective ink or film.

On all signs produced by direct or reverse screened process pastes, and on which it will not interfere with the message, the notation "PROPERTY STATE OF CALIFORNIA" shall be screened on to the face of the sign. The notation shall be in ¼ inch letters, with a visible border, and shall be placed in the lower center of the sign face in a manner not to interfere with the message or bolt holes.

D. Drawings

Standard signs shall be made in accordance with the reduced detail drawings furnished to the Contractor by Caltrans. Such drawings shall be considered to be part of these specifications. All other signs shall be made in accordance with drawings furnished by Caltrans or as mutually designed and agreed to by the Contractor and Caltrans. All sign layouts shall be the Contractor's responsibility and shall be subject to Caltrans' approval.

E. Warranty

The Contractor at no cost to the State shall replace any sign delivered under this Contract which does not conform to these specifications. Replacement includes cost of a new sign, removal and reinstallation. Signs will be supplied by the Contractor and replaced by State forces.

III. MINIMUM REQUIREMENTS

A. Retroreflective sheeting selected by the Contractor shall comply with the following requirements:

1. Description

The retroreflective sheeting shall consist of materials approved by Caltrans and shall conform to the requirements in ASTM Designation: D4956, except as may be noted elsewhere in these specifications. As an alternative to the artificial weathering apparatus described, a Light-Exposure Apparatus (Xenon-Arc Type) as described in ASTM Designation: G155, Xenon Arc Weatherometer with exposure conditions listed in Table X3.1, Cycle 1, may be used. The retroreflective sheeting performance requirements of D4956 shall apply.

The retroreflective sheeting shall be of the type that can be applied to the sign substrate (in accordance with the recommendations of the retroreflective-sheeting manufacturer) using either (a) an approved vacuum applicator using a combination of vacuum and heat, or (b) a squeeze roller applicator.

Type II retroreflective sheeting shall be backed with Class 1, Class 2, Class 3, or Class 4 pre-coated adhesive, when so specified, which will adhere to flat, clean, sign surfaces. Type III and IV retroreflective sheetings shall be backed with Class 1, Class 3, or Class 4 pressure sensitive adhesive only. The precoated adhesive shall be protected by an easily removed liner, shall have no staining effect on the retroreflective sheeting, and shall be mildew resistant.

The retroreflective sheeting shall have sufficient strength so that it can be handled, processed, and applied (according to the recommendations of the sheeting manufacturer) without appreciable stretching, tearing or other damage.

2. General Characteristics

The retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process inks at temperatures of 60 degrees to 100 degrees Fahrenheit and relative humidities of 20 percent to 80 percent. Retroreflective sheeting shall be heat resistant and permit force curing at temperatures recommended by the sheeting manufacturer. The retroreflective sheeting as supplied, stored under normal conditions, shall be suitable for use for at least one year after purchase.

3. Coefficient of Retroreflection (Retroreflective Intensity)

Minimum retroreflective intensities of the retroreflective sheetings after sign fabrication shall comply with the requirements for the respective sheeting types as stated and according to the methods in ASTM Designation: D4956.

The initial values of retroreflective intensity for screened sign face surfaces shall meet the requirements for sheeting type and color as specified in ASTM Designation: D4956.

4. Color and Luminance Factor (Y%)

After sign fabrication, the colors and luminance factors of the highway signs as specified herein shall conform either to the Color Specification Limits in Table 10 and respective Luminance Factors in Tables 2 and 6 as specified in ASTM Designation: D4956, or the Federal Highway Administration's Color Tolerance Chart.

The instrumental method of determining color shall conform to the requirements specified in ASTM Designation: D4956. In the event of any dispute concerning the results of instrumental testing, the visual test shall prevail.

5. Solvent Resistance (After Sign Fabrication)

The sign face shall be solvent resistant to cleaning solvents recommended by the manufacturer of the retroreflective sheeting. The manufacturer's recommendations shall be shown in the Contractor's Quality Control Program outlined in Section II.B. – Contractor's Quality Control" of these specifications.

6. Durability and Qualification

The Contractor shall provide documentation to the Transportation Laboratory that the sheeting will meet the Accelerated Outdoor Weathering Requirements and Colorfastness in Sections 6.4 and 6.5 of ASTM Designation: D4956. In addition the sign will be expected to maintain the minimum values for coefficient of retroreflection listed in Table 1 in Section III A.7.c. – "Field Performance Requirements" of these specifications for the expected service life of 10 years.

Retroreflective sheeting, processed with screening inks or process pastes where applicable, applied to approved sign base materials, and cleaned in accordance with the manufacturer's recommendations, shall meet the Colorfastness and coefficient of retroreflection requirements for sheeting type and color in ASTM Designation: D4956. Artificial Accelerated Weathering data as described in Section S3 may be substituted for outdoor weathering data.

The retroreflective sheeting presently being manufactured or marketed by the following firms have been evaluated and found to comply with the foregoing specifications:

1) Avery Dennison – T-2500 Series - Type II

2) Kiwalite - Type II
3) Nikkalite - 1800 Series - Type II
4) Nikkalite Brand Ultralite Grade II - Type III
5) 3M - Series 3800 - Type III
6) Avery Dennison -- T-5500 Series – Type III
7) Avery Dennison – T-6500 Series - Type IV
8) Avery Dennison – T-7500 Series – Type VIII
9) 3M VIP 3990 Series – Type IX

7. Performance Requirements and Obligations

a. Certification

The manufacturer of the retroreflective sheeting shall provide a Certificate of Compliance for each lot of retroreflective sheeting. The certificate shall be provided to representatives of the Caltrans Transportation Laboratory at the time of sign inspection at the Contractor's plant. The certificate shall be signed by the appointed representative of the manufacturer and shall state that the retroreflective sheeting complies in all respects with the requirements of these specifications.

The lot of sheeting so certified shall be clearly identified in the certificate. The certificate shall include the test data generated for the lot to indicate compliance to all the requirements stated within these specifications for the retroreflective sheeting.

b. Identification

A coding system shall be developed which will clearly identify each lot of sheeting and the manufacturer of the sheeting. The system employed for use on the sheeting shall also be used for application as identification on the back of the signs as required in Section II.C. – "Sign Identification" of these specifications. This coding system shall be detailed in the Contractor's Quality Control Program outlined in Section II.B. – Contractor's Quality Control" of these specifications.

c. Field Performance Requirements

Retroreflective sheeting, and screen printed transparent colored areas on white sheeting, processed and applied to sign blank materials in accordance with the sheeting manufacturer's recommendation, shall perform effectively for the number of years stated in Table I of this specification. The sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: 1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal daytime and nighttime driving conditions; 2) any of the requirements set in Sections III.A.4, III.A.5, and III.A.6 of these specifications are not met; or 3) the coefficient of retroreflection is less than the minimum specified for that sheeting during the period listed in the applicable table. Retroreflective values are given in candelas per foot candle per square foot ($cd/fc/ft^2$) at 0.2° observation angle and -4° entrance angle. All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

TABLE I

MINIMUM COEFFICIENT OF RETROREFLECTION
Type II Sheeting

Color	Ten Years
White	50
Yellow	35
Red	10

Green	10
Blue	3

MINIMUM COEFFICIENT OF RETROREFLECTION
Type III Sheeting

Color	Ten Years
White	200
Yellow	136
Red	36
Green	36
Blue	16

MINIMUM COEFFICIENT OF RETROREFLECTION
Type IV Sheeting

Color	Ten Years
White	200
Yellow	136
Red	28
Green	28
Blue	16

d. Contractor's Replacement Obligation

Where it can be shown that retroreflective traffic signs with retroreflective sheeting and inked screen printed signs supplied and used in accordance with the sheeting manufacturer's recommendations have not met the performance requirements of ASTM Designation: D4956 or these specifications the Contractor shall cover restoration costs during the ten year life time.

B. Substrate (Aluminum)

1. Description

The base metal shall be new sheet aluminum of alloys 6061-T6 or 5052-H38 conforming to the requirements of ASTM Designation: B 209.

The thickness of the aluminum sheet shall be 0.063 inches or 0.080 inches as specified in "Framing Requirements for Single Sheet Aluminum Signs" (Sheet 1) of these specifications. The material shall be subject to inspection prior to degreasing operations. Alloy and temper designations shall be verified by mill certification.

2. Fabrication

The fabrication of all metal parts shall be accomplished in a uniform and workmanlike manner. The sign panels are to be cut as shown on the sign specification sheets. The dimensional tolerance of the panels shall be plus or minus 1/16 inch. Metal panels shall be cut to size and shape and shall be free of buckles, warps, dents, cockles, burrs, and any other defects resulting from fabrication. Base plates for Standard Size Route Shield signs shall be die cut. All possible fabrication, including shearing, cutting and punching of holes shall be completed prior to the base metal pretreatment.

3. Pretreatment

The front and back surfaces of the aluminum base metal shall be cleaned, deoxidized, and coated with a light, tightly adherent chromated conversion coating free of any powdery residue. The base metal pretreatment process shall be in conformance with Section 5, "Recommended Processing Methods" of ASTM Designation: B 449. The coating weight shall be Class 2 (10-34 mg/ft^2), with a median of 25 mg/ft^2 as the optimum coating weight.

All treatment tanks or spray applied pretreatment systems shall be charged with fresh chemicals at least once a year. If pretreatment is performed by immersion methods, the tanks shall be of sufficient size to accommodate the complete panel. Titration equipment shall be available for the inspector's use to check the solution strengths. The cleaned and coated base metal shall be handled only by a mechanical device or by operators wearing clean cotton or rubber gloves. After cleaning and coating operations, the panels shall be protected at all times from contact or exposure to grease, oils, dust or other contaminants.

Other pretreatment methods similar to those specified above may be used providing prior approval is obtained from the Transportation Laboratory.

C. Substrate (Fiberglass Reinforced Plastic)

1. Description

Fiberglass Reinforced Plastic for sign panels shall be new and shall conform to the following requirements.

a. The sign panel shall be a fiberglass reinforced thermoset polyester laminate. The panel shall be acrylic modified and U.V. stabilized for outdoor weatherability.

b. The panel shall be stabilized to prevent the release of migrating constituents (i.e. solvents, monomers, etc.) over time and shall contain no residue release agents on the surface of the laminate so that neither migrating constituents nor release agents will be present in amounts that will interfere with any subsequent bonding operations.

c. The panel shall not contain visible cracks, pinholes, foreign inclusions, or surface wrinkles that would affect implied performance, alter the specific dimensions of the panel or otherwise affect its serviceability.

2. Mechanical Properties

a. All mechanical properties are stated as minimum requirements. The mechanical properties are measured in both the line direction of the panel and at 90° to the line as noted in the appropriate ASTM test referenced.

b. Averaged

Mechanical Property	Minimum Requirements	ASTM Test
Tensile Strengths	10.0 psi x 10^3	D638
Tensile Modulus	1.2 psi x 10^6	D638
Flexural Strength	20.0 psi x 10^3	D790
Flexural Modulus	1.2 psi x 10^6	D790
Compression Strength	32.0 psi x 10^3	D695
Compression Modulus	1.4 psi x 10^6	D695
Punch Shear	13.0 psi x 10^3	D732

3. Physical Properties

a. Thickness – Panels shall be 0.135 inches thick with tolerance of ±0.005 inches.

b. Size – (length and width) – Panel tolerance on nominal length and width specified by the purchaser shall be ±1/8 inch for dimensions of 12 feet or less when measured in accordance with ASTM D3841.

c. Squareness – Panels shall be within 1/8 inch of square per 12 feet of length when measured in accordance with ASTM D3841.

d. Smoothness – Panels shall be manufactured with smooth surfaces on both the top and bottom of the panel.

e. Color – Panel shall be pigmented to a visually uniform gray color within the Munsel range of N.7.5/ to N.8.5/.

f. Coefficient of Linear Thermal Expansion – Panels shall have a maximum coefficient of linear thermal expansion of 1.8 x 10-in./in./Fahrenheit when tested in accordance with ASTM D696.

g. Weather Resistance – Panels shall be classified as to a minimum Grade II (weather resistant) panel as specified in ASTM D3841-80 following a 3,000 ±100 hour weatherometer test.

h. Fire Resistance – The Fiberglass Reinforced Plastic traffic control sign panel shall contain additives designed to be less responsive to fire ignition and flame propagation. As such, the extent of burning shall not exceed 1.0 inches when tested in accordance with ASTM Method D635.

i. Flatness – Panels shall have a maximum deflection of 0.5 inches when tested in accordance with the following:

This test is performed to determine the potential for warpage in Fiberglass Reinforced Plastic panels for traffic signs.

The test requires five 30-by-30 inch Fiberglass Reinforced Plastic panels. Initial warpage shall be measured in four directions: 0^o, 45^o , 90^o and 135^o. To measure warpage, the panel shall be freely suspended at one corner, and a straight edge shall be placed along the panel so that the edges of the panel touch the straight edge. Care must be exercised so as not to disturb the dimensional characteristics of the panel. A rule graduated in fractional inches shall be used to measure the distance from the center of the panel face to the straight edge. That distance shall be measured to the nearest 1/32 inch in all four directions.

The panels shall be then freely suspended diagonally in an oven for 48 hours at 180 degrees Fahrenheit. After 48 hours in the oven, the panels shall be removed and allowed to cool to room temperature freely suspended. Warpage measurements and corresponding direction shall be again recorded as described above.

j. Impact Resistance – The panel shall resist the impact of a 1.18 lb. ball dropped from 60 feet in accordance with ASTM D3841.

k. Thermal Stability – Panel strength and impact resistance shall not be appreciably affected over a temperature range of –65 degrees Fahrenheit to 212 degrees Fahrenheit.

4. Fabrication

Sign blanks shall be fabricated of a single piece of Fiberglass Reinforced Plastic unless otherwise specified. Fiberglass Reinforced Plastic shall be cut to proper sign blank size and bolt holes provided. All edges, including holes, shall be true and smooth.

5. Surface Preparation

Refer to material specification C.1.b.

The panel should be wiped with a damp cloth and allowed to dry completely prior to sheeting.

D. Screening Inks, Process Paste, and Protective Overlays

1. Restrictions

Unless otherwise prohibited, screening inks or process pastes can be used, in lieu of manufactured colors at the option of the sign manufacturer, to produce both the legend and background. Only the screened colors of green, blue, red, brown and black may be used.

Only those screening inks or process pastes recommended by the retroreflective-sheeting manufacturer shall be used. The manufacturer's recommendations shall be shown in the Contractor's Quality Control Program outlined in Section II.B. – Contractor's Quality Control" of these specifications.

It is the responsibility of the Contractor to assure that all proposed retroreflective sheeting, overlay film or coating, and inks are fully compatible with each other.

2. Outdoor Weatherability

The outdoor weatherability of the applied inks or pastes shall be comparable to the outdoor durability of the retroreflective sheeting as stated in Section III.A.6 – "Durability and Qualification" of these specifications.

3. Adherence

   No process inks shall be removed when tested by applying cellophane tape over a properly cured; color processed area and removing the tape with one quick motion at an angle of 90^{o}. The tape shall be 3M Company Scotch Brand Cellophane Tape Number 600, ¾ inch wide.

4. Solvent Resistance

   After proper curing, all screened sign faces shall be resistant to the solvents specified by the manufacturer of the retroreflective sheeting and the screening inks or process pastes. The manufacturer's requirements for solvent resistance shall be shown in the Contractor's Quality Control Program outlined in Section II.B. – Contractor's Quality Control" of these specifications.

5. Color

   The color of the screened sign face surface as specified shall conform to the Color Specification Limits and respective Luminance Factor requirements as specified in ASTM Designation: D4956, for the type and color of sheeting.

   The instrumental method of determining color shall conform to the requirements specified in ASTM Designation: D4956.

   A significant difference between day and nighttime color shall be grounds for rejecting the signs.

6. Coefficient of Retroreflection (Transparent Color)

   Transparent colored inks shall be processed and applied in accordance with the recommendations of the sheeting manufacturer. When tested in accordance with ASTM Designation: D4956, the minimum transparent color (red, blue and green) processed on white sheeting shall be not less than 80 percent of the values specified in ASTM Designation: D4956 using the values for 0.2° observation angle and -4° entrance angle, expressed in candelas per foot candle per square foot ($cd/fc/ft^2$) of processed area.

7. Surface and Gloss

The screened sign face surface shall be smooth and flat to facilitate cleaning and maintain the wet performance and shall exhibit an 85^{o} gloss rating of not less than 40 (ASTM D523).

8. Graffiti Protection

When requested, sign faces shall be protected from graffiti removal and cleaning solvents and compounds with a Caltrans approved Protective Overlay. Caltrans shall specify Standard Protective Overlay Film, Premium Protective Overlay Film, Spray-on Coating or no protective overlay on sign orders.

The Protective Overlays marketed or manufactured by the following firms have been evaluated and found to comply with the Caltrans' specifications and testing requirements for graffiti coatings.

Standard Protective Overlay Film
Safe-Face V15B-SAF
3M Scotchlite 1150A
Nikkalite #142

Premium Protective Overlay Film
Nikkalite EF-40801
Avery OL-1000
3M Scotchlite 1160A

Spay-On Coating
Tradewinds, Inc. KrystalKote

Products considered equivalent to those listed above may be substituted when matched components are used. Caltrans must agree to the substitution in writing. Such agreement does not relieve the Contractor of its responsibilities under Section II.E. – "Warranty" of these specifications and Section III.A.7.d – "Contractor's Replacement Obligation" of these specifications.

Matched components are protective overlay films or coatings specifically recommended by the manufacturer for use on its sheeting listed in Section III.A.6. – "Durability and Qualification" of these specifications. The recommendation shall be in writing from the manufacturer of the sheeting and made available to Caltrans by the Contractor upon request.

E. Sign Panel Fabrication

1. Legend and Border

Direct screened or reverse screened. The finished screened sign shall comply with all requirements of these specifications, including color and retroreflectivity.

Pressure sensitive retroreflective sheeting for legends and borders shall be of the same type as specified in Section III.A.1 -- "Description" of these specifications. Such sheeting shall comply with all requirements of these specifications, including color and retroreflectivity.

Black pressure sensitive non-reflective sheeting for legends and borders may be used in lieu of black process paste. The sheeting shall be a black vinyl material and shall be approved and recommended by the base sheeting manufacturer. The type of black vinyl material shall be listed in the Contractor's Quality Control Program outlined in Section II.B. – Contractor's Quality Control" of these specifications.

When field joining of panels is necessary, the layout of the legend should avoid overlapping of the joint. When overlapping cannot be avoided, the copy shall be applied over the joint while the sign is

completely laid out in the shop, then neatly cut along the joint to separate the copy across the joint. Copy shall not be delivered separately for field installation.

2. Splices – Retroreflective Sheeting

No finished sign panel shall have more than one splice and no splice shall fall within 2 inches of the sign edge. When splices do occur, the adjoining retroreflective sheeting shall be color matched under both incident and reflected light. For squeeze roller application, no splice other than that occurring in the manufactured roll of retroreflective sheeting will be allowed. For vacuum application, there shall be no splices in the retroreflective sheeting other than that occurring in the manufactured roll of retroreflective sheeting, on panels with a minor dimension of 48 inches or less. On all rectangular signs with a minor dimension of more than 48 inches, the splice shall be horizontal.

3. Finish

All surfaces exposed to weathering shall be free of any defects in the coating that may impair the serviceability or detract from the general appearance or color matching of the sign. The finished sign shall be clean and free from all router chatter marks, burrs, sharp edges, loose rivets, delaminated retroreflective sheeting and aluminum marks. Signs with any defects or damage that would affect their appearance or serviceability will not be acceptable.

No air pockets or bubbles shall exist between the sheeting and the substrate materials. No repairs shall be made to the face sheet without the approval of the State Inspector.

F. Frames

1. Details

All rectangular signs over 55 inches measured along the horizontal axis and all diamond-shaped signs 60 inches and larger shall be framed unless otherwise specified. The frame shall be constructed of aluminum channel or rectangular tubing. Channel members and tubing members shall not be intermixed on one sign frame.

For channel or tubing size, refer to Framing Details (Sheet Numbers 2, 4 and 5). All framing dimensions shall have a length tolerance of plus or minus 1/8 inch unless otherwise specified.

2. Splice – Panel

In the horizontal direction, unless otherwise specified, the sign panel must be a continuous sheet (no vertical splice is permitted). For signs greater than 48 inches in height, a horizontal splice is permitted. See Drawing Number 4 for location of the splice channel and rivet spacing.

3. Rivets

The frame shall be affixed to the sign with 3/16 inch diameter rivets, aluminum alloy 5052, of a type approved by the Transportation Laboratory. The type of rivets shall be listed in the Contractor's Quality Control Program outlined in Section II.B. – Contractor's Quality Control" of these specifications. The exposed face of the rivets shall be of a similar shade and compatible with the face color of the finished sign. Aluminum alloys having properties similar to those specified may be used providing prior approval is obtained. The rivets shall be placed through the face of the sign with the web of the channel placed against the back of the sign. The maximum rivet spacing shall be 8 inches on center. See rivet detail on attached drawings. No rivets shall be placed closer than ½ inch from edge of the aluminum face sheet. All rivets shall fall within the web of the channel frame.

4. Joints

All joints of the aluminum channel frame shall be welded with an inert gas shielded-arc welding process using 4043-electrode filler wire in accordance with good shop practice. The width of the filler shall be equal to the wall thickness of the smallest channel being welded.

IV. PATENTS

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, the Director of Transportation and its duly authorized representatives from all suits at law, or action of every nature for, or on account of, the use of any patented materials, equipment, devices or processes.